SYSTEM AND METHODS FOR PERMITTING OPEN ACCESS TO DATA OBJECTS AND FOR SECURING DATA WITHIN THE DATA OBJECTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of pending U.S. Patent Application No. 08/674,726, filed July 2, 1996, entitled "Exchange Mechanisms for Digital Information Packages with Bandwidth Securitization, Multichannel Digital Watermarks, and Key Management"; pending U.S. Patent Application No. 08/999,766, filed July 23, 1997, entitled "Steganographic Method and Device"; pending U.S. Patent Application No. 09/046,627, filed March 24, 1998, entitled "Method for Combining Transfer Function with Predetermined Key Creation"; pending U.S. Patent Application No. 09/053,628, filed April 2, 1998, entitled "Multiple Transform Utilization and Application for Secure Digital Watermarking"; pending U.S. Patent Application No. 09/281,279, filed March 30, 1999, entitled "Optimization Methods for the Insertion, Protection, and Detection of Digital Watermarks in Digital Data"; pending U.S. Provisional Application No 60/169,274, filed December 7, 1999, entitled "Systems, Methods And Devices For Trusted Transactions"; pending U.S. Patent Application No. 09/456,319, filed December 8, 1999, entitled "Z-Transform Implementation of Digital Watermarks"; pending U.S. Patent Application No. 09/545,589, filed April 7, 2000, entitled "Method and System for Digital Watermarking"; pending U.S. Patent Application No. 09/594,719, filed June 16, 2000, entitled "Utilizing Data Reduction in Steganographic and Cryptographic Systems" (which is a continuation-in-part of International Application No. PCT/US00/06522, filed March 14, 2000, which PCT application claimed priority to U.S. Provisional Application No. 60/125,990, filed March 24, 1999); International Application No. PCT/US00/21189, filed August 4, 2000 (which claims priority to U.S. Patent Application No. 60/147,134, filed August 4, 1999, and to U.S. Patent Application No. 60/213,489, filed June 23, 2000, both of which are entitled "A Secure Personal Content Server"), U.S. Patent Application No. 09/657,181, filed September 7, 2000, (Attorney Docket No. 066112.0132), entitled "Method And Device For Monitoring And Analyzing Signals"; U.S. Provisional Patent Application No. 60/234,199, filed September 20, 2000, (Attorney Docket

No. 066112.9999), entitled "Improved Security Based on Subliminal and Supraliminal Channels For Data Objects"; U.S. Patent Application No. 09/671,739, filed September 29, 2000, (Attorney Docket No. 066112.999A), entitled "Method And Device For Monitoring And Analyzing Signals"; and U.S. Patent Application No. _____ (Attorney Docket No. 031838.0010), entitled "Systems, Methods and Devices for Trusted Transactions," filed December 7, 2000. The previously identified patents and/or patent applications are hereby incorporated by reference, in their entireties.

In addition, this application hereby incorporates by reference, as if fully stated herein, the disclosures of U.S. Patent 5,613,004 "Steganographic Method and Device"; U.S. Patent 5,745,569 "Method for Stega-Cipher Protection of Computer Code"; U.S. Patent 5,889,868 "Optimization Methods for the Insertion, Protection, and Detection of Digital Watermarks in Digitized Data"; and U.S. Patent No. 6,078,664, entitled "Z-Transform Implementation of Digital Watermarks."

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to the monitoring and analysis of digital information. Specifically, the present invention relates to methods and systems for open access and secured data objects.

2. Description of the Related Art

A number of fundamental issues discourage copyright holders from making their works available for general dissemination while ensuring payment for those works. This is especially the case for copyrighted works that may be digitally sampled and made available to open networks such as the World Wide Web. Various technologies have been proposed that serve to address specific problem areas. A synthesis of these technologies may represent a reasonable approach given the nature of networks and computation.

SUMMARY OF THE INVENTION

Therefore, a need has arisen for a method for open access and secured data objects that overcomes the deficiencies of the related art.

According to one embodiment of the present invention, a method for securing a data object is disclosed. The method includes the steps of (1) providing a data object comprising digital data and file format information; (2) embedding independent data into a data object; and (3) scrambling the data object to degrade the data object to a predetermined signal quality level. The steps of embedding and scrambling may be performed until a predetermined condition is met. The method may also include the steps of descrambling the data object to upgrade the data object to a predetermined signal quality level, and decoding the embedded independent data. The additional steps of descrambling and decoding may be performed until a predetermined condition is met. The predetermined condition may include, for example, reaching a desired signal quality of the data object.

According to another embodiment of the present invention, a method for distributing a data signal is disclosed. The method includes the steps of (1) providing a data signal comprising digital data and file format information; (2) selecting a first scrambling technique to apply to the data signal; (3) scrambling the data signal using the first scrambling technique, resulting in a first-level degraded data signal; (4) creating a first descrambling key for the first-level degraded data signal based on the first scrambling technique; (5) selecting a second scrambling technique to apply to the first-level degraded data signal; (6) scrambling the first-level degraded data signal using a second scrambling technique, resulting in a second-level degraded data signal; and (7) creating a second descrambling key for the second-level degraded data signal based on the second scrambling technique.

According to yet another embodiment of the present invention, a method for distributing a data object is disclosed. The method includes the steps of (1) providing a data object comprising digital data and file format information; (2) encoding independent authentication data into the data object; and (3) manipulating the file format information based on at least one signal characteristic of the data object.

According to still another embodiment of the present invention, a method for distributing data signals is disclosed. The method includes the steps of (1) embedding independent data into a data object; (2) scrambling the data object; (3) distributing the scrambled data object; (4) distributing a predetermined key that

enables access to the data object; and (5) descrambling the scrambled data object with the predetermined key.

According to another embodiment of the present invention, a method for data signal distribution is disclosed. The method includes the steps of (1) applying a steganographic technique for embedding independent data into the data signal; (2) applying a scrambling technique selected from the group consisting of file format manipulation and partial encryption; and (3) generating a predetermined key.

According to another embodiment of the present invention, a method for bandwidth allocation is disclosed. The method includes the steps of presenting a plurality of data objects to a user, each data object having a security application, and linking at least a first data object to a second data object. The first data object may include, for example, advertising. A characteristic of the first data object may cause a change in the second data object.

According to another embodiment of the present invention, a system for securing data within a data object is disclosed. The system includes an embedder that embeds independent data into a data object; and a scrambler that scrambles the data object to degrade the data object to a predetermined signal quality level. The system may also include a descrambler that descrambles the data object to upgrade the data object to a predetermined signal quality level; and a decoder that decodes the embedded independent data.

According to another embodiment of the present invention, a system for distributing a data signal is disclosed. According to one embodiment of the present invention, the system includes a first selector that selects a first scrambling technique to apply to the data signal; a first scrambler that scrambles the data signal using the first scrambling technique, resulting in a first-level degraded data signal; a first key creator that creates a first descrambling key for the first-level degraded data signal based on the first scrambling technique; a second selector that selects a second scrambling technique to apply to the first-level degraded data signal; a second scrambler that scrambles the first-level degraded data signal using a second scrambling technique, resulting in a second-level degraded data signal; and a second

key creator that creates a second descrambling key for the second-level degraded data signal based on the second scrambling technique.

DETAILED DESCRIPTION OF THE INVENTION

Cryptography is typically used to establish confidence, data integrity and nonrepudiation of data. The basis for cryptography lies in the difficulty of solving certain mathematical relationships that may exist between the uncoded message (i.e., "plaintext") and the coded message (i.e., the "ciphertext"). A difference between general coding schemes (which are used, for example, to storage and/or transmission of data) and cryptographic schemes is the cryptographic schemes involve the exchange of a "secret." Symmetric cryptographic protocols permit (for example, "plaintext") to be randomly encoded ("ciphertext") in such a manner so as to allow successful deciphering only with a secret, or "key." With symmetric ciphering, security is held in the key, which performs both encryption and decryption. What remains is the distribution, or sharing, and protection of the key. The key may be associated with unique, or independent, data, such as passwords or biometric information, to further cover the secret in a manner that may be individualized to users or devices capable of interpreting the unique data. The addition of unique data to the key serves to increase the computational complexity of discovering the secret.

Techniques have been developed to address the distribution of the key over public or unsecure communications channels. RSA uses such asymmetric cryptography in that a private or secret key is used for encryption, and a public key, (whose relationship with the private key can only be determined with great computational activity), is used to enable decryption. While public key cryptography also introduces the ability to carry out digital signature calculations to affix a signature to the decrypted output to assure nonrepudiation, the computational requirements of public key cryptography, including application of digital signatures, is thought to be relatively expensive for certain applications.

Depending on the security issue being addressed, cryptography may be used to secure communications channels or to establish the identity of users of a given communications channel. Signatures represent a further embodiment of

tamperproofing data and there are a number of known specialized signature functions to achieve various goals (zero knowledge, one time, subliminal free, etc.). The issue of how to assimilate the ease and inexpensive nature of digital communications with secure forms of authentication is thus a problem for which many potential solutions exist. The digital copy problem, however, may be more appropriately addressed by combining cryptographic features with steganography. Steganography is the art of hiding something in plain view.

Efforts to introduce the data integrity features of cryptography with the data hiding features of steganography resulted in the advent of digital watermarking. Digital watermarking, based on steganographic ciphering, uses the cryptographic benefits of key creation with perceptual coding schemes to tamperproof digitally sampled data. Such data may include images, audio, video, multimedia, etc. While cryptographic protocol ensures that the transfer of data may be successfully authenticated, only secure digital watermarking may uniquely identify the data object in a manner consistent with the characteristics of the data. Thus, watermark encoders will likely differ for different media objects.

The similarities between watermarking and signature schemes represent how changes or modifications of the data to be secured are mapped to an output. With perceptible data, perceptual compression limits the effectiveness of signatures as the compressed signal will perceptibly and accurately represent the original signal while reducing irrelevant or redundant data. Signature schemes are not traditionally directed at handling this limitation. Steganographic ciphering or signature generation based on steganography, however, is so directed. Robust digital watermarking, thus, has additional security limitations regarding the survival of the watermark and its relationship with the authentic signal. Combining a robust open watermark ("ROW") with a fragile or forensic watermark for the same digitized signal enables both robustness and security parameters to be met.

Some known methods for ensuring data integrity rely on how much access is provided to users. A problem exists, however, in that many data objects are available in formats that lack any protocol for access restriction or uniqueness (to assist in auditing copies). The benefits of widespread digital signal processing has reduced the assumption that the data objects need to come from authentic, or

authorized, sources. Essentially, the reliance on bandwidth limitations to assure the security of large copyrighted files, such as music and video, has become moot as physically stored media is introduced to public networks such as the Internet. This is known as the digital copy problem, or "piracy."

A related problem is that many of the schemes once thought to handle this significant problem, under the rubric of digital rights management ("DRM"), are entirely dependent on the security of the access restriction protocol, while ignoring the ease at which "difference" attacks may be applied. A difference attack may be performed by comparing a common data object in secure (e.g., a watermarked CD) and unsecure (e.g., an unsecure, or legacy CD) formats to yield the secret key. Moreover, DRM solutions typically stop providing any level of access restriction when the data object is viewed or played by the user. Any claim to the contrary ignores the mathematical equivalence of ciphering with coding. Ironically, DRM solutions are increasingly designed with reduced computational requirements in order to meet economic realities. This means that cryptographic protocols are designed to handle secure communications, while digitally sampled copyrighted media is designed to be widely accessible. The ineffectiveness of bandwidth limitations to act as a "speed bump" for rampant unauthorized duplication and redistribution of copyrighted data is best demonstrated by the wild popularity of such file-sharing systems as Napster™, Gnutella, etc. The present invention provides an approach to combine various security techniques to address the need for open access of data objects while preserving data integrity and payment for the objects.

In cryptography, a number of techniques have been developed to address the difficulty of trusting a single entity with certain sensitive data. One technique, based on threshold cryptography, requires more than one entity to enable the decryption of data by breaking the decryption key into partial keys. For instance, sensitive financial information having an intendent risk for abuse with a single private key may be ameliorated by requiring more than one person to each provide a partial key in concert to decrypt the sensitive information. In steganography, the lack of present asymmetric embedding protocols, with the exception of nonlinear encoding techniques, is a direct result of the linearity of most

perceptual coding schemes. Examples of such nonlinear encoding techniques are described in U.S. Patent No. 6,078,664, entitled "Z-Transform Implementation Of Digital Watermarks," the disclosure of which is incorporated by reference in its entirety.

Cryptographic protocols may be used to increase data integrity in steganographic ciphers, as well as nonlinear coding schemes, such as those that may be described by z-transforms, and separation of watermark detection from decoding (as disclosed in U.S. Patent No. 6,078,664 and pending U.S. Patent Application No. 09/456,319). Nevertheless, computational overhead may ultimately limit how much security can be directed on watermarking keys. As with threshold cryptography, transfer function-based key generation offers part of the solution for the present invention. This may be analogized to breaking secrets into parts that, when combined, yield the secret. The secret, or key, for a transfer function-based manipulation of a signal may be broken into parts to enable dynamic pricing models or models of payments more closely representative of a network of users. In this way, it may be beneficial to price data signals based on time or number of users seeking the same data objects but perhaps at varying quality levels or by extension payment profiles (subscription, download, *a la carte*).

Transfer functions represent a class of functions that relate input data to output data. As used in this disclosure, the term "transfer function" is used in the format sense, that is, to refer to that class of transfer functions that is used to format input data for meaningful communication. A particular format may be chosen to emphasize subjective or perceptible measures, or both. When stored in a particular format, the data may be said to have an inherent granularity based on the characteristics of the format. The transfer function can be used to manipulate, or scramble, the input data, for example, based on at least one signal characteristic of the data object. That is, the input data is scrambled in a way that manipulates the input data at a level of its inherent granularity in accordance with its transfer function. See U.S. Patent Application No. 09/046,627, filed March 24, 1998, entitled "Method for Combining Transfer Function with Predetermined Key Creation," which disclosure is incorporated herein by reference.

Compression schemes may be optimized for any number of parameters, such as robustness, fidelity, speed, etc., and thus, due consideration must be given to the granularity of the data for the given format. The present invention seeks to manipulate data in a way that varies depending on the quality of the data being sought. Thresholds for this quality measurement enable robust models for security and payment as described herein.

Transfer functions can be used to manipulate data at the inherent granularity of the file format of the data. While formatting is intrinsically important, for many data operations, the formatting is a small subset of the overall data being represented. This is of concern because of the nature of how data is recognized in real world applications. For instance, radio broadcasts are freely accessible, but are delivered at a quality that is inferior to the original recording. For example, a song that is recorded on a Compact Disc may include frequencies ranging from 20 Hz to 22,000 Hz, but when played on a radio receiver, the reproduced song typically includes frequencies only in the range of about 300 Hz to about 16,000 Hz. Compact discs have a commercially-based market price, while radio broadcasts are "paid" for by advertising.

The difference in quality is not the sole determinant in how the audio signal may be valued. However, the ability to broadcast, or stream data, and enable discrete file sharing through the same communications channel, such as the World Wide Web, places the model of streaming and downloads in direct competition. Similarly, designing security to meet either model is a benefit of the present invention over the prior art. The reasoning behind such comparison, and, by extension, the benefits offered by the present invention, relate to how data is perceived by a potential audience of consumers. Additionally, the present invention contemplates the steps that need to be applied to assure that the link between perception and payment.

The inherent granularity of the file format of the data may be thought of as signal characteristics or signal features. The changes may be associated with a pseudo-random key, or a cryptographically-generated key or key pair, and may be distributed and handled by downstream parties using existing browser, viewer or player technologies. This is disclosed in U.S. Patent Application Ser. No.

09/046,627, entitled "Method For Combining Transfer Functions With Predetermined Key Creation," the disclosure of which is incorporated by reference in its entirety. A benefit of controlling the quality of a signal as it will be offered to a marketplace of participants may be an important consideration in determining pricing of the media. It is also a means for determining the quality threshold at which potential consumers may evaluate the data to make a purchasing decision. An important difference is that cryptography is not directed to the quality of the data, but only to access to the data.

The comparative computational benefit of subjecting a signal to transfer function-based security, where the key is permanently associated with the degraded signal, versus faster encryption, is related, indirectly, to the boosts in speed for probabilistic cryptography versus traditional cryptography. With transfer functions, the key is predetermined to having application to some aspect of how the signal is represented. With encryption, however, no such information exists in order to provide security to the ciphertext. Some speed improvements, such as those disclosed in U.S. Patent No. 6,081,597, the disclosure of which is incorporated by reference in its entirety, regard the introduction of probabilistic approaches to cryptography in order to speed processing times for both encryption and decryption. This approach, however, may not be attractive because it introduces additional potential weaknesses for various mathematical properties.

What is clear is that information, as it is currently protected or secured, needs to have many approaches because, from a business perspective, it is unclear why some information achieves higher financial returns than other information. Assuring open access with security concentrated on the object, (as with watermarking), or concentrated on the fidelity, (as with transfer functions), may be more appropriate in view of the lost opportunities caused by access restriction with straight cryptography. Enabling the interaction of users and sellers to buy or trade value, held in keys, to increase the quality of data objects, is a more market-based approach to a problem for which few answers currently exist. As well, it provides for a more robust approach to understanding just what is demanded on a network, even in bandwidth terms, and enables a market-based approach to accurately charge for bandwidth and content or data objects exchanged on that bandwidth. The

bandwidth is measured in bits per second, where higher valued bits increase the optimal pricing of that bandwidth, for any given instant of time.

A further difference is that any cryptography applied to a signal stream may not be related to the characteristics of the signal stream, or the channel for the signal stream, and thus may be more expensive to both the sender and receiver of the data. As well, the transfer function key is a function of the signal or how the signal will be distributed over a channel, so it may be easier to change the transfer function key than to replace the decryption software of receivers of the data. Intentional and intrinsic links between the granularity, or quality, of a signal and schemes for authentication or payment may also be used to enable threshold-based quality settings. Moreover, the transfer function may be handled by existing viewers or players because the format of the data is not changed, but only the quality of the material in the format is manipulated.

Examples of threshold-based security include subjecting a data signal to a transfer function-based manipulation associated with a cryptographically-generated key or key pair, and embedding unique, or independent, data in the signal stream that may be logically linked with the transfer function-based key. This combines transfer functions with steganographic embedding to force attacks on the signal being sought. The unique information may be short hashes that are both fast and assist in enabling payment of the signal stream upon purchase of the descrambling key. Each short hash could, for example, represent some predetermined value given some expectation that some of the hashes may be lost, but not to affect an overall pricing of the data object.

An example of this combination is as follows. A purchaser observing a scrambled signal stream (with predetermined quality manipulations based on the transfer functions applied) purchases a key. The key may be parameterized in a manner that is signal-specific. For example, planned broadcasts with prerecorded signals may be preanalyzed to enable a perceptible mask for hiding data. In addition, technology to buffer preanalysis for signals to enhance the processing speed of a subsequent likely request of a previously preanalyzed signal may be used. The signal may also be preanalyzed for levels of degradation based on specific transfer functions applied to the signal. Channel or time specific parameters, similar

to session keys as practiced in cryptography, may be similarly utilized where channels have different data objects with different signal-based characteristics that may be grouped more efficiently, such as video and audio. Time-specific parameters may simply foster differences between those objects that are relatively high in demand at a given time. Additionally, popular pay-per-view systems may be enabled with time dependent parameters. Similar to session keys disclosed for ensuring secure channels (SSL), sessions key applied to information may increase security or enable discrete payments to be made for various distributed data objects.

One way to measure the threshold of payment is to measure a unit of payment against the ability to steganographically embed enough information to perform a successful authentication of payment information. Signature schemes are generally computationally expensive by orders of magnitude versus message authentication codes or one-way hashes. Given a relationship between the perceptibility of a signal and the available space for successfully hiding authentication data, a tampered signal stream may suffer both further quality degradation and a failure of the authentication protocols supporting payment mechanisms. Any inverse relationship between the signal quality and the a decrease in the detectable number of payment-based hashes may be used to adjust signal quality parameters with payment parameters. Reasonable estimations for the cost and expense of embedding hashes, which may be quickly authenticated and reliably associated with payment, have been demonstrated in a variety of known micropayment schemes.

Digital signatures may also be incorporated at a higher computational cost to the overall system implementation (e.g., MicroMint, PayWord). See Security Protocols, International Workshop Cambridge, United Kingdom April 10-12, 1996, Lecture Notes in Computer Science, Vol. 1189 (Mark Lomas ed.). These schemes, however, do not integrate signal quality generally with payments. Embedding is largely ignored.

The embedding and scrambling may have some logical relationship that may form the basis of an allocation of bandwidth or even a means of establishing a price for the object, or a demand for the object. Both techniques provide a robust framework for authenticating and verifying the object's quality, as

well as how the network may dynamically adjust the pricing of the overall bandwidth/objects being demanded by users.

When a given signal contains relatively little noise, there is less space for information hiding, and a payment metric may be adjusted for commercially valued signals prior to broadcast to estimate a fair payment model based on measures of successful steganographic embedding of the payment information in discrete units of time. When a given signal contains relatively high noise, adjustments over the payment metric may be made. Alternatively, or in combination with embedded payment information, the distortion introduced by a transfer function may be logically associated with the payment and stored in a general session key, or in a series of keys propagated from the sender to the receiver in a discrete series. The receiver may be required to establish credentials for payment in addition to an identity for material that is deemed to require prior authorization by the sender. Alternatively, the material may be intended for an audience at a particular quality setting that is commercially free (e.g., "AM radio quality"). As another alternative, any of the audience members may purchase keys that have a logical relationship with predetermined commercial pricing (e.g., "CD quality" or live concert event). The present invention anticipates flexible pricing, open access of signal streams and measured relationships with the quality of the signal in the stream. Any channel-based or time-based restrictions on a given implementation may be flexibly manipulated to achieve either better pricing or receiver-sensitive demands to given data objects.

Essentially, the streamed data is openly accessible to any potential consumer at a degraded quality (e.g., there is "open access" to the streamed data in a scrambled or slightly scrambled state). Further, payment data or other such independent data is securely embedded within the stream (i.e., there may be secured data hidden within the data stream). Both embedding and scrambled state-dependent settings are contemplated by the present invention. Purchase of the descrambling key introduces a change to the authentication or payment data stream and enables immediate streamed payment to be initiated. Where streamed payment is not preferred, single payments or installment payments in credit or debt are also possible with embodiments of the present invention. Establishing a unique identifier

for the user or payment means, such as linking to a phone bill, credit card or alternative payment facility, may provide additional credentials for the seller to use.

The benefits of such a system (e.g., improved estimation of demand for a particular data object, reduced cost of security because of the open-access nature of the data objects, the ability to link quality to payment) are obvious given the difficulty in assessing the commercial value of any given data object, especially where the data object may be made available in a variety of quality settings, live or prerecorded, or demand-based access limitation (essentially, a direct correlation with requests for a given data object or object stream and the cost of "handling" all requests). For example, discrete data objects may have a variety of quality levels, ranging from an encrypted version (low quality) to commercial grade quality. The quality levels may be predetermined, and may also include embedded data, which may have a variable detection rate based on the predetermined quality threshold. In addition, the present invention provides a tighter, more granular estimation of data object demand, as well as a clearer estimation of how a network can be optimized to realize commercial returns. All of this makes it so that different quality levels, different objects, differential object treatment for objects, which may be advertising instead of the content sought (for those situations where the channel may have a fixed dimension and part of the that fixed dimension includes data objects not being sought but being provided to pay for the object or objects being sought—his is called secondary or advertising-based data), yield-based pricing and demand given that the objects may be available in less-than-commercial grade quality instead of no access whatsoever for systems in the art.

The present invention also permits greater flexibility. For instance, the transfer function may be engineered to reduce perceptible artifacts as more people choose to pay. In other words, as more consumers pay, the overall level of quality of the stream increases. In another example, the scrambled states may be preset to make adjustments as users make payments for descrambling keys. Alternatively, threshold-like application of the transfer function may enable true market-based pricing of a particular signal or signal stream as access is unfettered to the initially, but intentionally, degraded signal. Moreover, the link with bandwidth costs, which may serve as a floor for the overall pricing of the objects being offered,

may constitute part of the embedded authentication data prior to purchase (by the user's decision to acquire a descrambling key).

In the case where the data is unknown, such as with new copyrighted material, it may be impossible to combine the signal degradation features of transfer functions if all of the data in a signal stream are subjected to cryptographic ciphering as is currently a predominant feature in the prior art. The material is all treated equally and thus the lowest common denominator is security with encryption and access restriction. Differential access is not possible based on signal quality measures and encrypting individual objects is a greater overall cost paid in the computational complexity of full encryption versus transfer function-based manipulations. The present invention uses transfer functions as a low-cost means for enabling open access to varying data objects, albeit in a downgraded level of quality intrinsic to the characteristics of the data, so as to allow for purchase decisions that may be made "on-the-fly." Another baseline may be made for the embedding features contemplated herein. The advent of robust open watermarks represents a fairly good representation of how a watermark may survive given a wide breadth of signal manipulations and subjective imperceptibility measures. A ROW may be engineered to survive up to the limit of the signal quality expected, including perceptual coding (e.g., MP3, AAC, etc.), and may serve as a baseline for the least amount of quality for a given signal intended for streaming. Essentially, the signal quality may be represented as that quality for which a ROW, which survives a predetermined number of signal manipulations, may be successfully embedded and detected.

The purchase is the equivalent of the receipt of the cryptographically generated transfer function-based key, or public key, by the user. The key may be dependent on the channel, as a session key for rendering the channel at a pre-transfer function state, where all objects in the channel are deemed equivalent, as with a concert broadcast, or predetermined quality, where some objects are less degraded, or not degraded, to encourage user interest in the channel.

The present invention may also be used to scramble particular data objects within a stream that offers higher quality in the stream (e.g., high definition television versus satellite television) than is otherwise available in other

predetermined formats (e.g., standard NTSC quality material of the same television broadcast, or even differences between live versus prerecorded material). Scrambled and unscrambled objects may be streamed in the same channel without the need for expensive cryptographic operations. Embedding authentication information in the stream, or including authentication information in the descrambling key, is economically inexpensive while being intrinsically dependent on the signal being sought.

The decision to use such data scrambling instead of full-blown encryption represents a decision to handle data objects as they are, not as the channel handles data absolutely. Thus, the choice of transfer function-based scrambling may be less prone to generic attacks on an encryption system that addresses data, but does not address data characteristics. Encryption systems may suffer implementation weaknesses if a general encryption method encrypts each data object independent of a comparably inexpensive coding system. Thus, for each encrypted object, there is an underlying coded element that has either been "wrapped" by an encryption function, a file extension, or that each coded element is encrypted, independent on the underlying coding scheme. Hacks will be focused on the objects as they are decrypted without any penalty paid on the data object or its quality (represented in signal features or characteristics based on characteristics, such as, frequency, time, spatial, or bit depth). Total Recorder, Audio Jacker and similar applications simply route decrypted signal outputs to unsecure locations in a receiver's general computing device, without the encryption. Comparisons with the previously encrypted stream are now computational easy to enable generalized hacks of the system keys.

Distributing security both perceptibly and imperceptibly is largely missing from the art. If encryption is expensive, it must offer a level of security consistent with that value. Authentication protocols need not be expensive in comparison to the coding scheme used by the receiver. Additionally, the present invention allows for considerations to be made for transfer functions that are bound by a communications channel (a higher number of channels may be utilized with smaller bandwidth requirements, but may also reduce the audience experience for each channel by lowering overall quality). To address this issue, a data object may

be preanalyzed to map any manipulations, given demand in the channel, to the coding scheme for which the channel is designed. If partial encryption is deemed a better security fit, instead of transfer functions, an encryption scheme that typically has no relationship with the scrambling of data given signal features or characteristics may be applied. Fast encryption schemes, such as elliptic curve or those disclosed in U.S. Patent No. 6,081,597, are good candidates.

Data objects may be communicated efficiently given an estimation of bandwidth resources. The trade-off among the size of the data objects, bandwidth capacity in available channels, and accessibility by receivers of the data objects create parameters for cost and performance. Depending on what data is broadcast in a stream, a variety of security protocols may be desired. Copyrighted material seeks the highest economic value by first reducing the cost of distribution, and then ensuring as much payment as possible. The cost of distribution is a function of both recognition and accessibility. Material that is demanded may not be communicated efficiently over networks for which senders and receivers have limited bandwidth (defined as bits per second, or data per discrete unit of time) prior to those users dropping from the system and potentially choosing not to make any purchase. Alternative means for accessing the material, including purchasing the material in a physical format that handles the bandwidth limitations more effectively (e.g., a prerecorded DVD), act as a physical representation of the bandwidth resources necessary to satisfy consumers. The devices that are designed to store the encoded objects may be configured to handle the embodiments of the present invention. Alternatively, markets exist for distribution of material in downgraded formats as a result of bandwidth limitations. Examples, such as Real Networks or Microsoft Media Player applications, offer material in formats that have lower absolute quality than that offered by such physical media packaging as CD and DVD. There also exist proprietary networks with higher channel capacity, such as cable television or satellite.

The problems of securing a stream of data are similar to securing a stored or fixed representation of the same. U.S. Patent No. 6,009,176, the disclosure of which is incorporated by reference in its entirety, offers a means for propagating a signature calculation across a stream of data. The computational cost of generating

the signature is reduced as the authentication features of the signature, or additionally generated one way hashes, in the stream are propagated as ancillary data. Essentially, a hash from a successive block of streamed data is embedded in the current block. The evident weakness of this technology is the computational overhead of signature propagation. While it is less intensive than discretely signing individual blocks, the weakness of authenticating a stream of data intended for broadcast is related to the inability to prevent the ancillary authentication information from being stripped. A more appropriate application of authentication trees, where an initial hash may apply to any of the children data, at lower computational cost, is the scrambling of data objects by transfer function. Application of such authentication in the stream of data itself is the basis of steganographic ciphering disclosed elsewhere in the art, including inventions by the present inventor.

A similar general observation is that authentication may be handled in a rudimentary way by observing any damage to an outputted stream. Similarly, crude authentication is possible when observing noisy, unpaid, cable television broadcasts. Dissimilarly from the present invention, it is believed that the application of data object specific scrambling, applicable to a streaming channel, affords rightsholders an extra measure of security in the absolute. For example, the threshold for dissuading consumers from observing media in downgraded formats has been historically inadequate. Second, it is assumed, arguendo, that observation is more likely to lead to purchase for a number of applicable markets. However, making data objects uniquely secure is less computationally expensive than a blanket application of any authentication or security scheme meant to address the most determined attacks for several reasons. For instance, not all objects are valued equally, and thus variable security protocols reduce the burden on aggregators or sellers of said objects. Next, quality has always been used to encourage recognition and purchasing of data objects such as media-rich content. Further, channels may be spilt between data objects intended for the channel matched with advertisements that are typically secondary in value to the user. The ability to mix the quality of both primary and secondary data objects being delivered to users in real time enables additional flexibility in pricing and service offerings to markets for data. Lastly, the

present invention seeks to tie layered security, while enabling open access, so as to reduce the potential for system-wide failure. By addressing each data object in context with the means for availability to potential consumers the purchasing experience may be enhanced in a manner consistent with existing markets for informational goods. This includes teasers, try-before-you buy, downgraded samples, combinations of content with advertising in the same channel, etc.

SAMPLE EMBODIMENTS

In order to better appreciate and understand the present invention, the following sample embodiments are provided. These sample embodiments are provided for exemplary purposes only, and in no way limit the present invention.

Sample Embodiment 1

Although this sample embodiment may be described in relation to digital music and video, it should be noted that the present invention is not so limited.

According to one embodiment of the present invention, a secured data object that may contain digital music or video, or both, may contain independent data embedded within. For purposes of this embodiment, digital music having an initial signal quality level equivalent to that of a compact disc is provided.

Independent data, which may include authenticatable data, such as a robust open watermark, may be embedded into the digital music. This may be accomplished by any known technique. The digital music is then scrambled in order to obscure embedded data. The scrambling also degrades the signal quality of the digital music.

The scrambling may be used to degrade the signal quality by a predetermined amount. For example, the scrambling may decrease the signal quality one step, or level, such as from CD quality to MP3 quality; MP3 quality to FM quality; FM quality to AM quality; and AM quality to telephone quality. For video, this may include, inter alia, NTSC quality, QuickTime quality, Macrovision quality, satellite quality, and DVD quality.

The steps of embedding independent data and scrambling the digital music may be repeated as desired until a predetermined condition, such as a desired signal quality level, is reached.

In one embodiment, the digital music may be distributed to users with a degraded signal quality in order to promote the digital music. For example, users may be able to download the digital music with a degraded signal quality (e.g., telephone quality, AM radio quality, etc.) for free in order to evaluate the music. If the user likes the music, the user may purchase the ability to upgrade the signal quality level of the digital music. This may be done in steps (e.g., from telephone quality to AM radio quality, then AM quality to FM quality, etc.) or it may be done in one instance (e.g., telephone quality to CD quality).

Keys may be used to upgrade the signal quality. As a user purchases a key, the key is used to decode the independent data from the digital music. This data may include payment information.

The keys may be used singularly, or they may be used collectively. When used singularly, a key may be used by an individual user to increase the signal quality of the digital music, or a key may be used to initiate a session key-based timing mechanism. In the latter situation, the session key may provide a user with a unit of time of high quality digital music.

When used collectively, the keys may be used to increase the signal quality of the digital music for a group. For example, as more users purchase keys to decode the music, the signal quality of the digital music is upgraded for all. In addition, the keys may be pooled to initiate a session key-based timing mechanism.

The pricing of the keys may be based on several pricing models. For example, factors, including, inter alia, signal quality, bandwidth required to transmit the digital music, etc., may be used in determining the pricing of a key.

Sample Embodiment 2

Several companies give consumers the option of receiving advertisements in lieu of making a direct payment for the services that the companies provide. Examples of these services include EverAd for music, NetZero and Juno for Internet access, etc. The present invention provides a way to bridge a

pay service with an advertisement delivery service, to create an individual mix for each consumer.

At a base quality level, the user may be required to view a complete advertising package, using the maximum amount of screen space available. As the user pays for increased quality levels, the quantity and size of the advertisements decrease, until at full quality and/or full payment the advertisements disappear. The quality/advertisement ratio may be individual for each data object as well as each consumer.

This embodiment offers several significant advantages. First, the pricing of the system may be optimized for each object individually. Second, the advertisements may be served as a stream, which may necessitate the consumer to periodically connect to the ad server, thus maintaining the integrity of the data objects and allowing for regular key switching.

Sample Embodiment 3

Pay-per-view streams are one of the ways in which cable and satellite providers create additional revenue from their existing bandwidth. The present invention provides the ability to offer a pay-per-view event at a degraded quality until a key purchase was made. Each key purchase incrementally increases the quality of the stream. Additionally, the keys may be switched at predetermined intervals, such as 1 second, to allow higher quality "teasers" to induce purchase. For example, a consumer may view a one-time preview at the higher quality for 1 or 2 minutes by receiving the relevant keys. This may entice the consumer to purchase the higher quality stream.

Sample Embodiment 4

The present invention may provide the ability to combine several separate channels into a single window. According to one embodiment, a plurality of channels or data objects with varying applications of security may be provided to a web browser. An example of such includes a web browser with a channel of scrambled audio, watermarked advertising, and watermarked images that may be viewed and/or listened to by the user.

The advertising may be linked to the audio channel in a manner that is different from radio advertising. For example, the advertising channel may have a logical link to the audio stream. A user may purchase a higher quality audio signal by purchasing session keys that are linked to the scrambling state or to the embedded watermarks. The session keys may represent payments. Either one of the session keys, or the session keys collectively, may yield authenticatable data, embedded hashes or data related to the descrambling key(s), which may be converted in a logical manner, such as a payment estimator or "yield"-type measure, to dynamically adjust the overall payment for the channel in question.

Each channel may have different data object elements, and may be different for each user. The common thread for the channel may simply be the channel name. Thus, some channels may have data objects that have primary value (content) and secondary value (advertising), or may contain a specific media type (e.g., video, audio, etc.).

The yields may be personalized for a user given the fact that certain entities or aggregators of content may have many different data objects to offer in a maximal mix that appeals to individuals or markets. In one embodiment, certain media types may have a better yield (measured in bits/second) than other media types. An example of this is digital music versus digital video. Digital video generally has a certain number of bits, while digital video has a different number of bits. The market prices for these media types are different and the time or times consumers choose to listen or view means that the value in bits/second is different. Similarly, an advertisement has a certain bandwidth profile that is measured in terms of pricing given marketing parameters.

To the user, it is all an allocation of bandwidth given that consumers have a fixed amount of time and money to decide which media types and how much fidelity or discreteness (media size) the user should choose in either real time, as with a network, or in fixed prerecorded units (CDs, versus DVDs, versus recording media to handle MP3, all different media sizes given resources available to consumers and how a media company decides to occupy the bits).

Sample Embodiment 5

Network optimization protocols, including such technologies as caching and store and forward models for handling the allocation of bandwidth, or more particularly data objects, are based largely on estimating demands for data objects by a plurality of users who may be connected to the network in variety of ways. These users may have differing demands based on connection speed and other limitations for accessible bandwidth. The ability to dynamically handle the keys described in the present invention, including scrambling and embedding in some predetermined manner, also serves to enable network operators to better determine what quality levels are sought on a per data object basis, and how payments can be estimated, given user requests for keys that link quality and payment to the objects themselves. The variety of data objects, based on media type and bandwidth (measured in terms of bits per second and some predetermined quality level), is constantly monitored to assure the best use of bandwidth for any given network. By extension, the present invention enables any existing network to be based more closely on dynamic pricing models and dynamic handling of data object dependent or channel based keys to establish real time quality levels sought but those with access to the network.

Other embodiments and uses of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. The specification and examples should be considered exemplary only with the true scope and spirit of the invention indicated by the following claims. As will be easily understood by those of ordinary skill in the art, variations and modifications of each of the disclosed embodiments can be easily made within the scope of this invention as defined by the following claims.